SECTION 6

Preliminary Drainage Service Alternatives

6.1 Introduction

As described in Section 4, preliminary alternatives consist of combinations of the drainage service options. The options are combined to create ***complete*** alternatives, using the three broad conceptual alternatives developed in the Functional Analysis Workshop: In-Valley Disposal, Out-of-Valley Disposal, and Beneficial Use. A ***complete*** alternative is one that includes all necessary components (options) to manage, treat, and dispose of drainwater and its constituents.

Within each conceptual alternative, a number of sub-alternatives are possible that combine options in different ways (consistent with the concept) and target different quantities of drainwater within the projected range of drainage need. As an example for the In-Valley Disposal alternative, sub-alternatives could be differentiated by the treatment or disposal method (e.g., traditional evaporation pond vs. solar gradient pond), by the method of selenium treatment (if any), or by the level of drainage volume reduction achieved prior to disposal.

This section describes an array of possible sub-alternatives for each of the conceptual alternatives. A few of the sub-alternatives were selected for more detailed discussion, summarizing their physical characteristics and costs. These sub-alternatives were selected as being representative of the conceptual alternatives. Preliminary cost estimates are associated with each of the selected sub-alternative based on the conceptual-level cost estimates prepared for the individual options. The purpose of the cost estimates is to provide an idea of the approximate magnitude of the total capital and operational costs associated with the preliminary alternatives. The costs do not include the full environment mitigation costs, although some sub-alternatives have some mitigation costs included. As alternatives are more fully developed in the next phase of work, the mitigation costs will become better defined.

6.2 Common Features and Assumptions

In cost estimates done for each alternative, the costs for on-farm drainage system installation and operation were included. (Based on escalation of costs reported in earlier studies, installation cost would be approximately $890 per acre and operational cost would be about $8 per acre per year). Drain water collection and conveyance costs are also shown for each representative alternative in Section 6.5. For reporting purposes the on-farm drainage system and off-farm collection and conveyance costs have been combined. Indirect costs (or benefits) to crop production caused by changing drainage conditions were not estimated. No attempt was made in this phase of the report to allocate costs among entities or to explore financial implications.

6.3 Land Retirement

Land retirement is not considered as a drainage service option in this Report. It is included as a drainage management component in some Preliminary Alternatives to reduce the capacity of drainage service needed. Land retirement was assessed and described extensively in earlier studies (SJVDP, 1990; Reclamation, 1991). It consists of converting to other uses irrigated lands that contribute a very high loading of salts or trace constituents. Those uses might include dryland agriculture, wildlife habitat, or fallowed land.

For purposes of this Report, retired land is assumed to require no irrigation and to produce no subsurface drain water. The cost of retiring land is driven largely by the market value of land. Land values can vary substantially, depending on soil quality, salinity problems, access to water, structures, etc., and depending on whether land is valued with project water and drainage costs. Recent prices paid by Reclamation's Land Retirement Program are approximately $2400-$2600 per acre, including the CVP water entitlement. Westlands Water District paid Reclamation $1150 per acre to retain the water entitlement. Westlands has implemented its own program to retire land, and has recently paid $1500 per acre. (R. May, 2001). Additional costs must be incurred to manage lands that are purchased.

6.4 Preliminary Alternatives and Sub-Alternatives

The sub-alternatives were formed to generate incremental cost differences for each of the alternatives. To generate these differences, the key parameters varied were the drainage rate per drained acre, the area served, and the disposal method.

The sub-alternatives shown are based on feasible combinations of options that can provide complete drainage service, and are the result of review of previous studies, recent research, and expert judgment. A detailed analysis of how the options work together physically and operationally will be done as part of the detailed Plan Formulation and EIS process that follows this Preliminary Alternatives Report.

6.4.1 In-Valley Alternatives

Table 6-1 summarizes the In-Valley alternatives. These alternatives are characterized by ultimate salt disposal either to landfills or deep well injection. Landfilling salts is a proven technology with many Valley landfills interested in accepting these salts. For the landfill sub-alternatives it was assumed the salts would be in dry form versus a brine. The dry salts can be accepted by Class II landfills and the costs of hauling or transporting the weight of water would be avoided. Consequently, all of the landfill sub-alternatives also include evaporation ponds.

To get a range of potential size configurations for evaporation ponds to landfill, four sub alternatives were developed, all with different volumes of drainage going to the evaporation ponds:

- Drainage based on current irrigation technology going to the evaporation ponds and ultimately disposed in landfills

TABLE 6-1
In-Valley Alternatives

Designation	Drainage Rate (af/acre)	Description of Alternative	Area Served (acres)	Collected Volume (acre-feet)	Treatment Volume (acre-feet)	Treatment Methods	Disposal Volume (acre-feet or tons)	Disposal Method
1A	0.3	Evaporation pond to landfill	260,600 drained 0 retired	78,200	78,200	Evaporation Ponds	480,000 Tons	Landfill
1B	0.5	Evaporation pond to landfill	260,600 drained 0 retired	130,300	130,300	Evaporation Ponds	480,000 Tons	Landfill
1C	0.3	Integrated Drainage Management to Evaporation Ponds to Landfill	260,600 drained 0 retired	78,200	7,820	Integrated Drainage Management and Evaporation Ponds	480,000 Tons	Landfill
1D	0.5	Large Scale Land Retirement to Evaporation Ponds to Landfill	60,600 drained 200,000 retired	30,300	30,300	Land Retirement and Evaporation Ponds	62,000 Tons	Landfill
1E	0.5	Selective Land Retirement to Evaporation Ponds to Landfill	210,600 drained 50,000 retired	105,300	105,300	Land Retirement and Evaporation Ponds	380,000 Tons	Landfill
1F	0.3	Integrated Drainage Management to Deep Well	260,600 drained 0 retired	78,200	7,820	Integrated Drainage Management	7,820 AF	Deep Well
1G	0.5	Large Scale Land Retirement to Deep Well	60,600 drained 200,000 retired	30,300	30,300	Land Retirement	30,300 AF	Deep Well

- Drainage after enhanced irrigation management going to the evaporation ponds and ultimately disposed in landfills.
- Drainage after integrated drainage management going to evaporation ponds and ultimately disposed in landfills
- Land retirement with drainage from the remaining acres based on current irrigation technology going to evaporation ponds and ultimately disposed in landfills.
- Drainage based on current irrigation technology with disposal of drainage using deep well injection

The other In-Valley disposal method is deep well injection. Two deep well injection sub-alternatives were developed; one assuming drainage based on current irrigation technology going to deep well injection, the other assumed sequential reuse with the remaining drainage going to deep well injection.

6.4.2 Out-of-Valley Alternatives

Table 6-2 summarizes the Out-of-Valley alternatives. The two Out-of-Valley disposal sites for the sub-alternatives were the Delta and the ocean. The Delta sub-alternatives were developed for three different sizes under these scenarios:

- Delta
  - Drainage based on current irrigation technology going to selenium treatment and ultimate disposal in the Delta
  - Drainage after enhanced irrigation management going to selenium treatment and ultimate disposal in the Delta
  - Drainage from integrated drainage management going to selenium treatment and ultimate disposal in the Delta
- Ocean Disposal
  - Drainage based on current irrigation technology with ultimate disposal going to the Ocean
  - Drainage after enhanced irrigation management with ultimate disposal going to the Ocean
  - Drainage from integrated drainage management with ultimate disposal going to the Ocean
  - Land retirement with drainage from the remaining acres using current irrigation technology with ultimate disposal going to the ocean

TABLE 6-2
Out-of-Valley Alternatives

Designation	Drainage Rate (af/acre)	Description of Alternative	Area Served (acres)	Collected Volume (acre-feet)	Treatment Volume (acre-feet)	Treatment Methods	Disposal Volume (acre-feet or tons)	Disposal Method
2A	0.3	Selenium Treatment to Delta	260,600 drained 0 retired	78,200	78,200	Selenium Treatment	78,200 AF	Delta
2B	0.5	Selenium Treatment to Delta	260,600 drained 0 retired	130,300	130,300	Selenium Treatment	130,300 AF	Delta
2C	0.5	Integrated Drainage Management to Delta	260,600 drained 0 retired	130,300	13,030	Integrated Drainage Management	13,030 AF	Delta
2D	0.3	Ocean	260,600 drained 0 retired	78,200	78,200		78,200 AF	Ocean
2E	0.5	Ocean	260,600 drained 0 retired	130,300	130,300		78,200 AF	Ocean
2F	0.3	Selenium Treatment to Ocean	260,600 drained 0 retired	78,200	78,200	Selenium Treatment	78,200 AF	Ocean
2G	0.5	Selenium Treatment to Ocean	260,600 drained 0 retired	130,300	130,300	Selenium Treatment	130,300 AF	Ocean
2H	0.5	Integrated Drainage Management to Ocean	260,600 drained 0 retired	130,300	13,030	Integrated Drainage Management	13,030 AF	Ocean
2I	0.5	Large Scale Land Retirement to Ocean	60,600 drained 200,000 retired	30,300	30,300	Land Retirement	30,300 AF	Ocean

TABLE 6-3
Beneficial Use Alternatives

Designation	Drainage Rate (af/acre)	Description of Alternative	Area Served (acres)	Collected Volume (acre-feet)	Treatment Volume (acre-feet)	Treatment Method	Disposal Volume (acre-feet or tons)	Disposal Method
3A	0.3	Reverse Osmosis with Brine to Landfill	260,600 drained 0 retired	78,200	78,200	Reverse Osmosis	480,000 Tons salt 59,000 acre-feet water available	Landfill
3B	0.5	Reverse Osmosis with Brine to Landfill	260,600 drained 0 retired	130,300	130,300	Reverse Osmosis	480,000 Tons Salt 98,000 acre-feet water available	Landfill
3C	0.5	Integrated Drainage Management to Reverse Osmosis with Brine to Evaporation Ponds to Landfill	260,600 drained 0 retired	130,300	13,030	Integrated Drainage Management to Reverse Osmosis	480,000 Tons Salt 10,000 acre-feet water available	Landfill
3D	0.5	Integrated Drainage Management to Reverse Osmosis with Brine to Evaporation Ponds to Salt Reuse	260,600 drained 0 retired	130,300	13,030	Reuse to Reverse Osmosis	480,000 Tons Salt 10,000 acre-feet water available	Salt Reuse
3E	0.5	Large Scale Land Retirement to Reverse Osmosis with Brine to Evaporation Ponds to Landfill	60,600 drained 200,000 retired	30,300	30,300	Reverse Osmosis	63,000 Tons Salt 23,000 acre-feet water available	Landfill

6.4.3 Beneficial Use Alternatives

Table 6-3 shows the Beneficial Use alternatives. All the sub-alternatives included reverse osmosis to create a clean water byproduct, and one sub-alternative considered the use of the salts. These sub-alternatives were:

- Drainage based on current irrigation technology going through reverse osmosis treatment with the brine to evaporation ponds and ultimately disposed inland fills
- Drainage based on enhanced irrigation management going through reverse osmosis treatment with the brine to evaporation ponds and ultimately disposed in landfills and the clean product water going to a beneficial use
- Drainage from integrated drainage management going through reverse osmosis with the brine to evaporation ponds and ultimately disposed in landfills and the clean product water going to a beneficial use
- Land retirement with drainage from the remaining acres using current irrigation technology going through reverse osmosis treatment with the brine to evaporations and ultimately disposed in landfills and the clean product water going to a beneficial use
- Drainage from integrated drainage management going through reverse osmosis treatment with the brine to evaporation ponds, with the dried salts going to a beneficial use and the clean product water going to a beneficial use

6.5 Descriptions and Cost Estimates of Representative Alternatives

Tables 6-1, 6-2, and 6-3 summarize the features of 21 possible alternatives for drainage service, representing a number of possible combinations of treatment and disposal options. In the following sub-sections, nine of these are described in more detail to present a more manageable but representative range of possible drainage solutions. The representative alternatives are not necessarily the most desirable or least costly – that judgment will not be made until more detailed evaluation and impact assessment are completed in the next phase of study. None of the options or alternatives developed in this Report has been screened out during this phase. The short list of representative alternatives described below includes four in-valley, three out-of-valley, and two beneficial use alternatives. All of the representative alternatives are scaled to treat and dispose of all subsurface drainage from the San Luis Unit; to the extent that existing surface channels and streams could continue to be used to discharge drain water from the Northern Districts, total costs shown below would be reduced.

6.5.1 In-Valley Alternative 1B

Figure 6-1 shows the drainage treatment and disposal steps included in Alternative 1B.

FIGURE 6-1
Schematic of Drainage Service Features at Build-out, Representative Alternative 1B

Drained Area and Drainage Volume. At build-out of the drainage system, 260,600 acres are served by subsurface drainage collection and conveyance. On-farm irrigation and drainage management uses current technology, resulting in an assumed average drainage rate of 0.5 acre-feet per drained acre. The resulting volume of sub-surface drainage would be 130,300 acre-feet per year. The area and volume drained would increase over the development period, estimated to reach the build-out levels after about 36 years (see Section 3).

Collection and Conveyance System. The San Luis Unit Drainage Program (Reclamation, 1991) estimated the cost to collect and convey subsurface drainage in Westlands Water District to centralized evaporation pond sites. In 1990 dollars, construction costs were about $927 per drained acre, and Operation and Maintenance (O&M) costs were about $10 per acre per year. These costs do not include on-farm tile drainage systems. Escalated to 2001 dollars, drainage collection and conveyance costs are estimated to be $1,240 construction cost per drained acre and $12 O&M cost per drained acre per year. The drained area in the Northern Districts already has collection and conveyance facilities. Although some re-design or renovation may be required to convey drainage from this area to evaporation ponds, such costs have not been estimated in this phase of study.

Treatment or Volume Reduction Approach. Alternative 1B would treat all subsurface drainage using evaporation ponds. For purposes of this description, traditional evaporation pond design is assumed, although the evaporation process could use a solar-gradient or enhanced evaporation design. Assuming an average of four acre-feet of evaporation per acre of pond, over 28,810 acres of ponds would be required at build-out to service the projected drainage volume from both Westlands and the Northern Districts. Based on updated cost estimates described in Appendix B, construction costs would be about $2,050 per acre of evaporation pond, and annual O&M would be $50 per acre per year. These costs do not include salt disposal.

Salt Disposal. Alternative 1B would dispose of salts accumulated in the evaporation ponds by excavating it and trucking it to an existing landfill. According to estimates from the San Luis Unit Drainage Program (Reclamation, 1991), salts would not accumulate to the point of requiring excavation and disposal for about 40 years. Given the time lag, it is unclear which of the existing landfills would be available for the disposal of salts from evaporated drain water. For purposes of this Report, it is assumed that a Class 2 landfill would be required. Hauling distance is approximately 55 miles from the Mendota area. Salts removed to a landfill are assumed to be 80 percent salt/20 percent water by weight, so the total mass of material to be transported is estimated at about 480,000 tons per year. Cost of waste disposal is estimated to be $20 per ton going into landfill, plus an additional $100 per ton for excavation and hauling.

6.5.2 In-Valley Alternative 1C

Figure 6-2 shows the drainage treatment and disposal steps included in Alternative 1C.

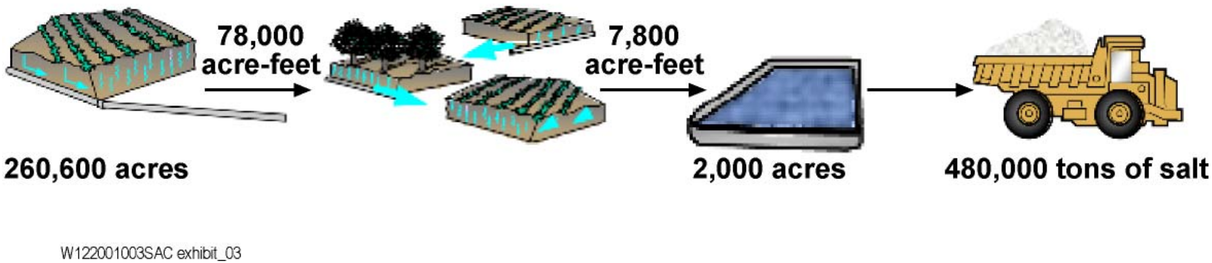

FIGURE 6-2
Schematic of Drainage Service Features at Build-out, Representative Alternative 1C

Drained Area and Drainage Volume. At build-out of the drainage system, 260,600 acres are served by subsurface drainage collection and conveyance. On-farm irrigation and drainage management uses best available technology, resulting in an assumed average drainage rate of 0.3 acre-feet per drained acre. The resulting volume of sub-surface drainage requiring service would be 78,200 acre-feet per year. The area and volume drained would increase over the development period, estimated to reach the build-out levels after about 36 years (see Section 3).

Collection and Conveyance System. The San Luis Unit Drainage Program (Reclamation, 1991) estimated the cost to collect and convey subsurface drainage in Westlands Water District to centralized evaporation pond sites. In 1990 dollars, construction costs were about $927 per drained acre, and Operation and Maintenance (O&M) costs were about $10 per acre per year. These costs do not include on-farm tile drainage systems. Escalated to 2001 dollars, drainage collection and conveyance costs are estimated to be $1,240 construction cost per drained acre and $12 O&M cost per drained acre per year. The drained area in the Northern Districts already has collection and conveyance facilities. Although some re-design or renovation may be required to convey drainage from this area to IDM facilities and evaporation ponds, such costs have not been estimated in this phase of study.

Treatment or Volume Reduction Approach. Alternative 1C would use a number of Integrated Drainage Management systems to reduce the volume of drain water by reusing it on salt tolerant crops. Effective IDM systems can reduce the volume of drain water by up to 90 percent from its original volume. Capital costs of an IDM system are estimated to be about $80 per acre-foot per year of influent drainage water, and an additional $70 per acre-foot per year of O&M cost, totaling about $150 per acre-foot per year. Prototype IDM systems have demonstrated that about 87,000 acres of salt tolerant crops would be required at build-out to service the projected drainage volume from both Westlands and the Northern Districts.

The concentrated drain water leaving the IDM facilities would then be conveyed to evaporation ponds. For purposes of this description, traditional evaporation pond design is assumed, although the evaporation process could use a solar-gradient or enhanced evaporation design. Assuming an average of four acre-feet of evaporation per acre of pond, approximately 2,000 acres of ponds would be required at build-out to service the projected drainage volume from both Westlands and the Northern Districts. Based on updated cost estimates described in Appendix B, construction costs would be about $2,050 per acre of evaporation pond, and annual O&M would be $50 per acre per year. These costs do not include salt disposal.

Salt Disposal. Alternative 1C would dispose of salts accumulated in the evaporation ponds by excavating it and trucking it to an existing landfill. According to estimates from the San Luis Unit Drainage Program (Reclamation, 1991), salts would not accumulate to the point of requiring excavation and disposal for about 40 years. Given the time lag, it is unclear which of the existing landfills would be available for the disposal of salts from evaporated drain water. For purposes of this Report, it is assumed that a Class 2 landfill would be required. Hauling distance is approximately 55 miles from the Mendota area. Salts removed to a landfill are assumed to be 80 percent salt/20 percent water by weight, so the total mass of material to be transported is estimated at about 480,000 tons per year. Cost of waste disposal is estimated to be $20 per ton going into landfill, plus an additional $100 per ton for excavation and hauling.

6.5.3 In-Valley Alternative 1D

Figure 6-3 shows the drainage treatment and disposal steps included in Alternative 1D.

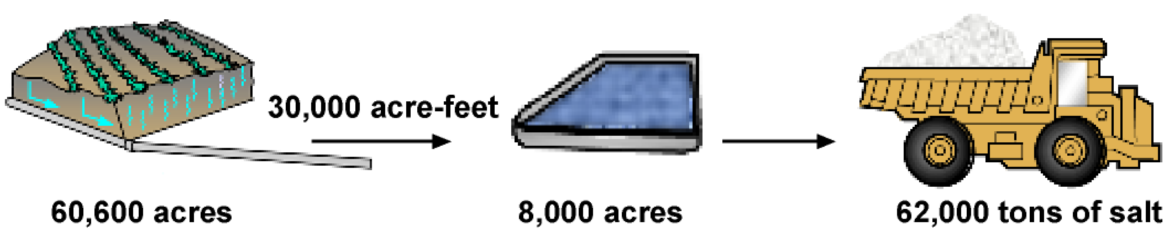

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FIGURE 6-3
Schematic of Drainage Service Features at Build-out, Representative Alternative 1D

Drained Area and Drainage Volume. Based on estimates described in Section 3 of this Report, over 260,000 acres would require some form of drainage service at build-out of the project. This alternative proposes to retire 200,000 acres of drainage-affected land. Assuming that no drainage service is needed on these lands, the remaining drained area would be 60,600 acres of currently drained lands in the Northern Districts. On-farm irrigation and drainage management would continue to use existing technology, resulting in an assumed average drainage rate of 0.5 acre-feet per drained acre. The resulting volume of sub-surface drainage requiring service would be 30,300 acre-feet per year. The area drained would remain constant during the planning horizon.

Collection and Conveyance System. The drained area in the Northern Districts already has collection and conveyance facilities. Although some re-design or renovation may be required to convey drainage from this area to evaporation ponds, such costs have not been estimated in this phase of study.

Treatment or Volume Reduction Approach. Alternative 1D would treat all subsurface drainage using evaporation ponds. For purposes of this description, traditional evaporation pond design is assumed, although the evaporation process could use a solar-gradient or enhanced evaporation design. Assuming an average of four acre-feet of evaporation per acre of pond, approximately 8,000 acres of ponds would be required at build-out to service the projected drainage volume from the Northern Districts. Based on updated cost estimates described in Appendix B, construction costs would be about $2,050 per acre of evaporation pond, and annual O&M would be $50 per acre per year. These costs do not include salt disposal.

Salt Disposal. Alternative 1D would dispose of salts accumulated in the evaporation ponds by excavating it and trucking it to an existing landfill. According to estimates from the San Luis Unit Drainage Program (Reclamation, 1991), salts would not accumulate to the point of requiring excavation and disposal for about 40 years. Given the time lag, it is unclear which of the existing landfills would be available for the disposal of salts from evaporated drain water. For purposes of this Report, it is assumed that a Class 2 landfill would be required. Hauling distance is approximately 55 miles from the Mendota area. Total mass load of salt in drain water at build-out is estimated to be about 50,000 tons from the Northern Districts. Salts removed to a landfill are assumed to be 80 percent salt/ 20 percent water by weight, so the total mass of material to be transported is estimated at about 62,000 tons per year. Cost of waste disposal is estimated to be $20 per ton going into landfill, plus an additional $100 per ton for excavation and hauling.

6.5.4 In-Valley Alternative 1G

Figure 6-4 shows the drainage treatment and disposal steps included in Alternative 1G.

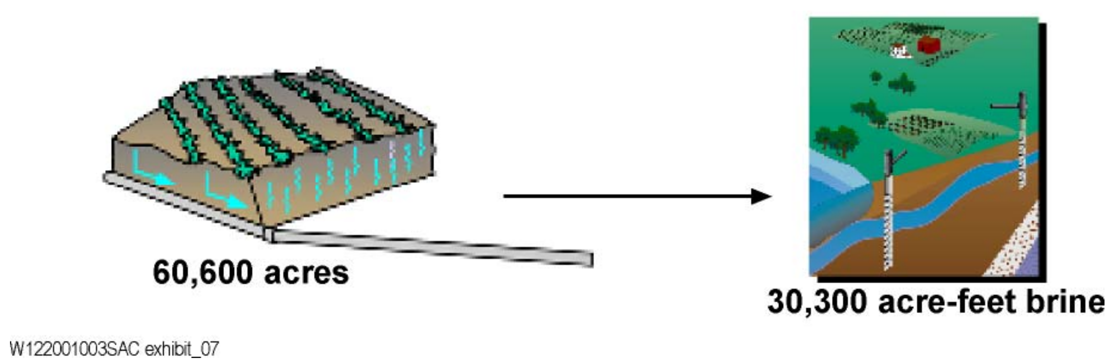

FIGURE 6-4
Schematic of Drainage Service Features at Build-out, Representative Alternative 1G

Drained Area and Drainage Volume. Based on estimates described in Section 3 of this Report, over 260,000 acres would require some form of drainage service at build-out of the project. This alternative incorporates the WWD proposal to retire 200,000 acres of drainage-affected land. Assuming that no drainage service is needed on these lands, the remaining drained area would be 60,600 acres of currently drained lands in the Northern Districts. On-farm irrigation and drainage management would continue to use existing technology, resulting in an assumed average drainage rate of 0.5 acre-feet per drained acre. The resulting volume of sub-surface drainage requiring service would be 30,300 acre-feet per year. The area drained would remain constant during the planning horizon.

Collection and Conveyance System. The drained area in the Northern Districts already has collection and conveyance facilities. Although some re-design or renovation may be required to convey drainage from this area to deep well injection sites, such costs have not been estimated in this phase of study.

Treatment or Volume Reduction Approach. Some pre-treatment of drain water may be required prior to injection. Costs of pre-treatment are included in the cost estimates for the deep well systems.

Drain Water and Salt Disposal. Alternative 1G would dispose of drain water by deep well injection.

6.5.5 Out-of-Valley Alternative 2B

Figure 6-5 shows the drainage treatment and disposal steps included in Alternative 2B.

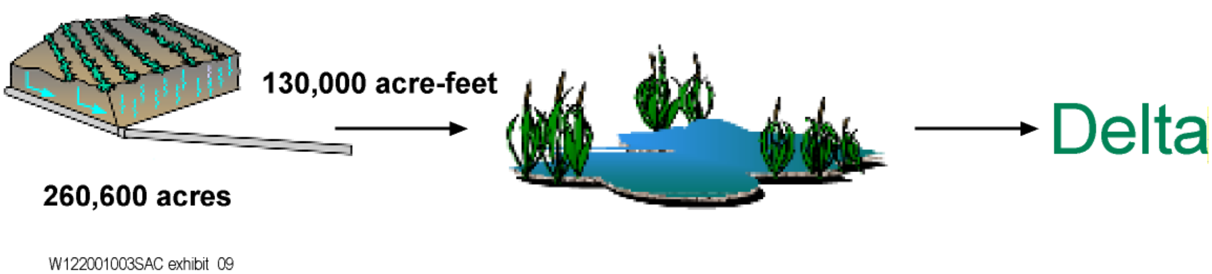

FIGURE 6-5
Schematic of Drainage Service Features at Build-out, Representative Alternative 2B

Drained Area and Drainage Volume. At build-out of the drainage system, 260,600 acres are served by subsurface drainage collection and conveyance. On-farm irrigation and drainage management uses current technology, resulting in an assumed average drainage rate of 0.5 acre-feet per drained acre. The resulting volume of sub-surface drainage requiring service would be 130,300 acre-feet per year. The area and volume drained would increase over the development period, estimated to reach the build-out levels after about 36 years (see Section 3).

Collection and Conveyance System. The San Luis Unit Drainage Program (Reclamation, 1991) estimated the cost to collect and convey subsurface drainage in Westlands Water District to centralized treatment sites. In 1990 dollars, construction costs were about $927 per drained acre, and Operation and Maintenance (O&M) costs were about $10 per acre per year. ***These costs do not include on-farm tile drainage systems.*** Escalated to 2001 dollars, drainage collection and conveyance costs are estimated to be $1,236 construction cost per drained acre and $12 O&M cost per drained acre per year. The drained area in the Northern

Districts already has collection and conveyance facilities. Although some re-design or renovation may be required to convey drainage from this area to Selenium treatment facilities, such costs have not been estimated in this phase of study.

Treatment or Volume Reduction Approach. Alternative 2A would treat all subsurface drainage having greater than 50 ppb of Selenium using one of the Selenium treatment options described in Appendix B. For purposes of this description, the Microalgal-Bacterial treatment process is assumed, although the other processes could be used if proven to be superior in cost or effectiveness. Based on cost estimates described in Appendix B, annual costs would be $300 per acre per year. These costs do not include disposal of algal sludge that accumulates in the ponds.

Drain Water Disposal. Alternative 2A would dispose of drain water by constructing a conveyance facility to the San Joaquin River Delta. This option was studied extensively in the past, and costs from those studies have been updated in Appendix B. Construction cost is estimated to total $370,000 million, including the cost of design, purchasing right-of-way, building the conveyance facility, and building the discharge facility. Annual O&M for the Delta discharge option is estimated to be $20 million per year for the assumed volume of drain water.

6.5.6 Out-of-Valley Alternative 2E

Figure 6-6 shows the drainage treatment and disposal steps included in Alternative 2E.

FIGURE 6-6
Schematic of Drainage Service Features at Build-out, Representative Alternative 2E

Drained Area and Drainage Volume. At build-out of the drainage system, 260,600 acres are served by subsurface drainage collection and conveyance. On-farm irrigation and drainage management uses current technology, resulting in an assumed average drainage rate of 0.5 acre-feet per drained acre. The resulting volume of sub-surface drainage requiring service would be 130,300 acre-feet per year. The area and volume drained would increase over the development period, estimated to reach the build-out levels after about 36 years (see Section 3).

Collection and Conveyance System. The San Luis Unit Drainage Program (Reclamation, 1991) estimated the cost to collect and convey subsurface drainage in Westlands Water District to centralized treatment or disposal sites. In 1990 dollars, construction costs were about $927 per drained acre, and Operation and Maintenance (O&M) costs were about $10 per acre per year. ***These costs do not include on-farm tile drainage systems.*** Escalated to

2001 dollars, drainage collection and conveyance costs are estimated to be $1,240 construction cost per drained acre and $12 O&M cost per drained acre per year. The drained area in the Northern Districts already has collection and conveyance facilities. Although some re-design or renovation may be required to convey drainage from this area to an ocean discharge conveyance facility, such costs have not been estimated in this phase of study.

Treatment or Volume Reduction Approach. Alternative 2E would not include any treatment or volume reduction prior to conveyance and discharge of drain water to the ocean.

Drain Water Disposal. Alternative 2E would dispose of drain water by constructing a conveyance facility to the Pacific Ocean. This option was studied extensively in the past, and costs from those studies have been updated in Appendix B. Construction cost is estimated to total $320 million, including the cost of design, purchasing right-of-way, building the conveyance facility, and building the discharge facility. Annual O&M for the Ocean discharge option is estimated to be $20 million per year for the assumed volume of drain water.

6.5.7 Out-of-Valley Alternative 2H

Figure 6-7 shows the drainage treatment and disposal steps included in Alternative 2H.

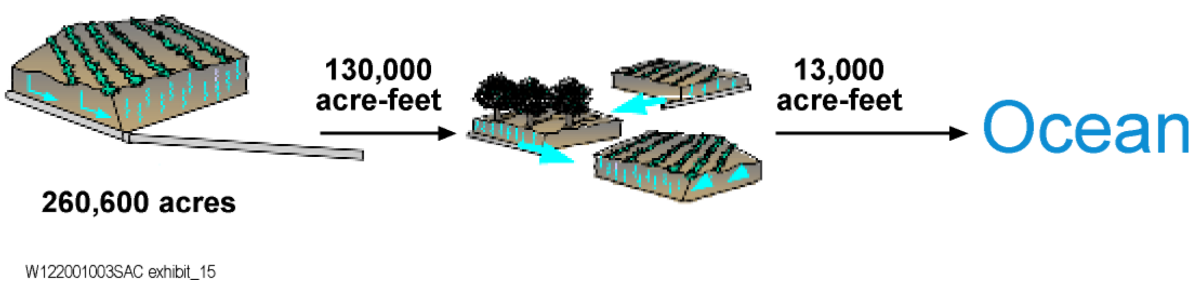

FIGURE 6-7
Schematic of Drainage Service Features at Build-out, Representative Alternative 2H

Drained Area and Drainage Volume. At build-out of the drainage system, 260,600 acres are served by subsurface drainage collection and conveyance. On-farm irrigation and drainage management uses current technology, resulting in an assumed average drainage rate of 0.5 acre-feet per drained acre. The resulting volume of sub-surface drainage requiring service would be 130,300 acre-feet per year. The area and volume drained would increase over the development period, estimated to reach the build-out levels after about 36 years (see Section 3).

Collection and Conveyance System. The San Luis Unit Drainage Program (Reclamation, 1991) estimated the cost to collect and convey subsurface drainage in Westlands Water District to centralized evaporation pond sites. In 1990 dollars, construction costs were about $927 per drained acre, and Operation and Maintenance (O&M) costs were about $10 per acre per year. ***These costs do not include on-farm tile drainage systems.*** Escalated to 2001 dollars, drainage collection and conveyance costs are estimated to be $1,240 construction cost per drained acre and $12 O&M cost per drained acre per year. The drained area in the

Northern Districts already has collection and conveyance facilities. Although some re-design or renovation may be required to convey drainage from this area to IDM facilities, such costs have not been estimated in this phase of study.

Treatment or Volume Reduction Approach. Alternative 2H would use a number of Integrated Drainage Management systems to reduce the volume of drain water by reusing it on salt tolerant crops. Effective IDM systems can reduce the volume of drain water by up to 90 percent from its original volume. Capital costs of an IDM system are estimated to be about $1,200 per acre-foot of influent drainage water, and an additional $70 per acre-foot per year of O&M cost.

Drain Water Disposal. Alternative 2H would dispose of drain water by constructing a conveyance facility to the Pacific Ocean. This option was studied extensively in the past, and costs from those studies have been updated in Appendix B. Construction cost is estimated to total $150 million, including the cost of design, purchasing right-of-way, building the conveyance facility, and building the discharge facility. Annual O&M for the Ocean discharge option is estimated to be $4 million per year for the assumed volume of drain water.

6.5.8 Beneficial Use Alternative 3A

Figure 6-8 shows the drainage treatment and disposal steps included in Alternative 3A.

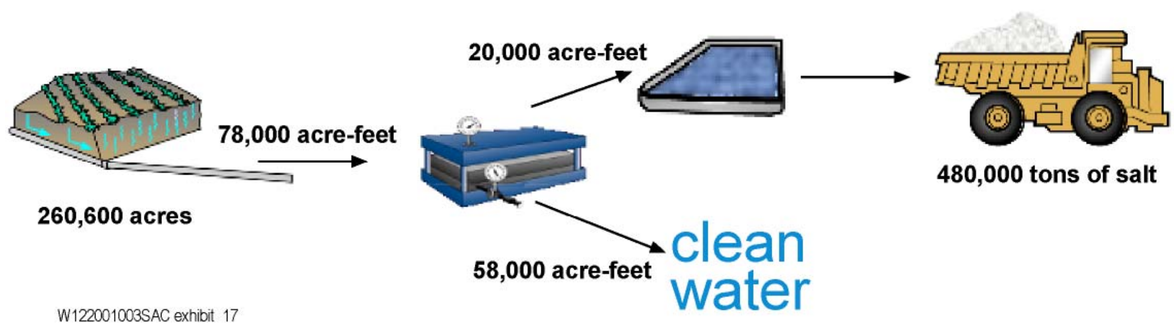

FIGURE 6-8
Schematic of Drainage Service Features at Build-out, Representative Alternative 3A

Drained Area and Drainage Volume. At build-out of the drainage system, 260,600 acres are served by subsurface drainage collection and conveyance. On-farm irrigation and drainage management uses enhanced technology, resulting in an assumed average drainage rate of 0.3 acre-feet per drained acre. The resulting volume of sub-surface drainage requiring service would be 78,200 acre-feet per year. The area and volume drained would increase over the development period, estimated to reach the build-out levels after about 36 years (see Section 3).

Collection and Conveyance System. The San Luis Unit Drainage Program (Reclamation, 1991) estimated the cost to collect and convey subsurface drainage in Westlands Water District to centralized treatment sites. In 1990 dollars, construction costs were about $927 per drained acre, and Operation and Maintenance (O&M) costs were about $10 per acre per year. *These costs do not include on-farm tile drainage systems.* Escalated to 2001 dollars, drainage collection and conveyance costs are estimated to be $1,240 construction cost per drained acre and $12 O&M cost per drained acre per year. The drained area in the Northern Districts already has collection and conveyance facilities. Although some re-design or renovation may be required to convey drainage from this area to RO facilities, such costs have not been estimated in this phase of study.

Treatment or Volume Reduction Approach. Alternative 3A would take the drainage collected from drained lands into a Reverse Osmosis (RO) desalting process. Costs for the RO process are highly sensitive to the concentration of influent water. Annual costs are estimated to be $680 per acre-foot.

The concentrated brine resulting from Reverse Osmosis would enter a second stage of treatment, evaporation ponds. Based on updated cost estimates described in Appendix B, construction costs would be about $2,050 per acre of evaporation pond, and annual O&M would be $50 per acre per year. These costs do not include salt disposal.

Drain Water and Salt Disposal. Alternative 3A would beneficially use the desalted water. The water represents a very high quality, reliable supply. Westlands Water District has been purchasing water from willing sellers for up to $150 per acre-foot delivered to the District; for purposes of this Report, $150 will be the assumed value of the water produced by the RO process. Landfill costs would be similar to those described for Alternative 1A.

6.5.9 Beneficial Use Alternative 3D

Figure 6-9 shows the drainage treatment and disposal steps included in Alternative 3D.

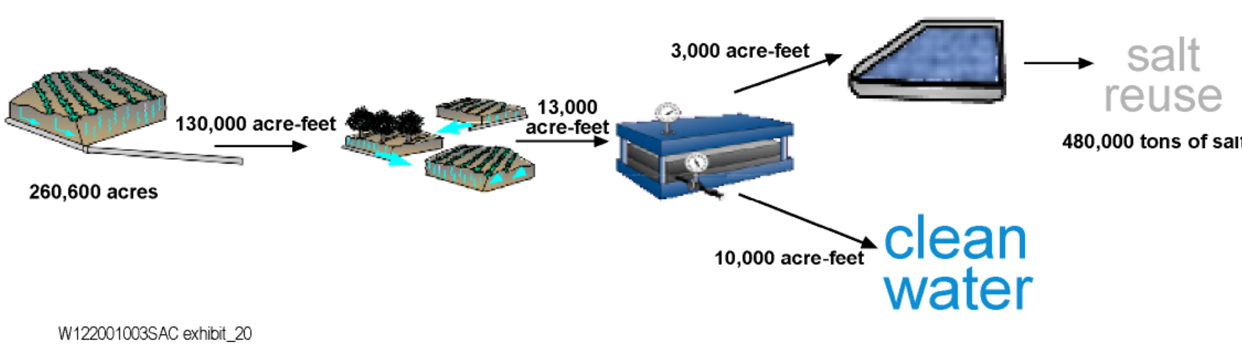

FIGURE 6-9
Schematic of Drainage Service Features at Build-out, Representative Alternative 3D

Drained Area and Drainage Volume. At build-out of the drainage system, 260,600 acres are served by subsurface drainage collection and conveyance. On-farm irrigation and drainage management uses current technology, resulting in an assumed average drainage rate of 0.5 acre-feet per drained acre. The resulting volume of sub-surface drainage requiring service would be 130,300 acre-feet per year. The area and volume drained would increase over the development period, estimated to reach the build-out levels after about 36 years (see Section 3).

Collection and Conveyance System. The San Luis Unit Drainage Program (Reclamation, 1991) estimated the cost to collect and convey subsurface drainage in Westlands Water District to centralized treatment sites. In 1990 dollars, construction costs were about $927 per drained acre, and Operation and Maintenance (O&M) costs were about $10 per acre per year. ***These costs do not include on-farm tile drainage systems.*** Escalated to 2001 dollars, drainage collection and conveyance costs are estimated to be $1,240 construction cost per drained acre and $12 O&M cost per drained acre per year. The drained area in the Northern Districts already has collection and conveyance facilities. Although some re-design or renovation may be required to convey drainage from this area to IDM or RO facilities, such costs have not been estimated in this phase of study.

Treatment or Volume Reduction Approach. Alternative 3D would use a number of Integrated Drainage Management systems to reduce the volume of drain water by reusing it on salt tolerant crops. Effective IDM systems can reduce the volume of drain water by up to 90 percent from its original volume. Capital costs of an IDM system are estimated to be about $1,200 per acre-foot of influent drainage water, and an additional $70 per acre-foot per year of O&M cost.

A second stage of treatment in this alternative would take the concentrated drainage resulting from an IDM system into a Reverse Osmosis (RO) desalting process. Costs for the RO process are highly sensitive to the concentration of influent water. Based on the high concentration of drainage from IDM, RO costs are estimated to be $680 per acre-foot.

The concentrated brine resulting from Reverse Osmosis would enter a third stage of treatment, evaporation ponds. Based on updated cost estimates described in Appendix B, construction costs would be about $2,050 per acre of evaporation pond, and annual O&M would be $50 per acre per year. These costs do not include salt disposal.

Drain Water and Salt Disposal. Alternative 3D would beneficially use the desalted water. The water represents a very high quality, reliable supply. Westlands Water District has been purchasing water from willing sellers for up to $150 per acre-foot delivered to the District; for purposes of this Report, $150 per acre-foot will be the assumed value of the water produced by the RO process.

This alternative assumes that a beneficial use can be found for salts produced from the drain water. Because of the high uncertainty associated with the potential market for salts, this Report assumes that they would be given away to a user, resulting in no further salt disposal cost to the San Luis Unit. (If no user could be found, landfill costs would be similar to those described for Alternative 1A.)

6.6 Summary of Cost Estimates for Representative Alternatives

Table 6-4 summarizes the costs for all the subalternatives. Costs shown represent total capital costs, annual operating costs, and the present worth of these costs over a 50-year period of analysis. These costs are subject to significant revision in the next phase of detailed study.

TABLE 6-4
Cost Summary

		Area Served (acres)			Capital Cost ($Million) [a]				Annual O&M&R and Energy ($Million) [a]				
Alternative Designation	Alternative Description	Drained	Retired	Collected Volume (AF)	Conveyance[b]	Treatment	Disposal	Land Retirement	Conveyance	Treatment	Disposal	Water Sales[c]	Total Present Worth ($ million)
In-Valley Alternatives													
1A	Evaporation Ponds to Landfill	260,600	0	78,180	555	41			5	4	57		$2,140
1B	Evaporation Ponds to Landfill	260,600	0	130,300	555	68			5	7	57		$2,227
1C	Integrated Drainage Management to Evaporation Ponds to Landfill	260,600	0	78,180	555	98			5	6	57		$2,238
1D	Large Scale Land Retirement to Evaporation Ponds to Landfill	60,600	200,000[d]	30,300	129	16		480	1	2	8		$805
1E	Selective Land Retirement to Evaporation Ponds to Landfill	210,600	50,000	105,300	449	53		120	4	5	45		$1,884
1F	Integrated Drainage Management to Deep Well	260,600	0	78,180	555	94	16		5	5	2		$908
1G	Large Scale Retirement to Deep Well	60,600	200,000[d]	30,300	129		61	480	1		9		$846
Out-of-Valley Alternatives													
2A	Selenium Treatment to Delta	260,600	0	78,180	491	156	370		5	4	12		$1,397
2B	Selenium Treatment to Delta	260,600	0	130,300	491	260	370		5	7	20		$1,742
2C	Integrated Drainage Management to Delta	260,600	0	130,300	491	313	120		5	18	4		$1,471
2D	Ocean	260,600	0	78,180	491		320		5		12		$1,119

TABLE 6-4
Cost Summary

		Area Served (acres)			Capital Cost ($Million) [a]				Annual O&M&R and Energy ($Million) [a]				
Alternative Designation	**Alternative Description**	**Drained**	**Retired**	**Collected Volume (AF)**	**Conveyance[b]**	**Treatment**	**Disposal**	**Land Retirement**	**Conveyance**	**Treatment**	**Disposal**	**Water Sales[c]**	**Total Present Worth ($ million)**
2E	Ocean	260,600	0	130,300	491		320		5		20		$1,308
2F	Selenium Treatment to Ocean	260,600	0	78,180	491	156	320		5	4	12		$1,351
2G	Selenium Treatment to Ocean	260,600	0	130,300	491	260	320		5	7	20		$1,696
2H	Integrated Drainage Management to Ocean	260,600	0	130,300	491	313	150		5	18	4		$1,498
2I[e]	Large Scale Retirement to Ocean	60,600	200,000[d]	30,300	491		150	480	5		9		$1,331
Beneficial Use Alternatives													
3A	Reverse Osmosis with Brine to Evaporation Ponds to Landfill	260,600	0	78,180	555	41			5	57	57	(9)	$3,214
3B	Reverse Osmosis with Brine to Evaporation Ponds to Landfill	260,600	0	130,300	555	16			5	90	57	(15)	$3,853
3C	Integrated Drainage Management to Reverse Osmosis with Brine to Evaporation Ponds to Landfill	260,600	0	130,300	555	279			5	18	57	(1)	$2,661
3D	Integrated Drainage Management to Reverse Osmosis with Brine to Evaporation Ponds to Salt Reuse	260,600	0	130,300	555	158			5	18		(1)	$1,166

TABLE 6-4
Cost Summary

Alternative Designation	Alternative Description	Area Served (acres)		Collected Volume (AF)	Capital Cost ($Million) [a]				Annual O&M&R and Energy ($Million) [a]				Total Present Worth ($ million)
		Drained	Retired		Conveyance[b]	Treatment	Disposal	Land Retirement	Conveyance	Treatment	Disposal	Water Sales[c]	
3E	Large Scale Land Retirement to Reverse Osmosis with Brine to Evaporation Ponds to Landfill	60,600	200,000[d]	30,300	129	4		480	1	21	8	(3)	$1,183

[a] Although some mitigation costs are accounted for, alternatives to be considered in more detail will require coordination with regulatory agencies and the public to determine an appropriate level of mitigation.

[b] Cost includes installation and maintenance of on-farm drainage systems.

[c] For the purpose of this report, it was assumed clean product water would be worth $150 per acre-foot.

[d] This reflects Westlands Water District's proposal to retire 200,000 acres of land.

[e] Designs for disposal of drainwater to the Delta or the ocean have not been completed in previous studies for this size.